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Stem Rust in 1938

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STEM RUST IN 1938

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Both stem rust and leaf rust were epidemic on wheat in 1938. Stem rust was unusually heavy in many of the principal grain-growing areas of the Southern and Central States, becoming particularly destructive in central Texas, in some fields of eastern Oklahoma, on soft wheat in northeastern Kansas, and in sections of eastern Nebraska. In much of northern Missouri soft wheat also was heavily rusted, although the loss was not so great as it was in 1937. The epidemic was severe in the spring wheat areas on susceptible varieties, reaching its greatest intensity in considerable areas of North Dakota. In other parts of the spring wheat States rust development was checked by the predominance of the resistant Thatcher wheat, as in Minnesota and in certain sections of northeastern North Dakota, or by hot dry weather, as in parts of North Dakota and South Dakota.

Losses to wheat as a result of stem rust were estimated at 10 percent for bread wheat in North Dakota and 5 percent in Montana and South Dakota. Spring wheat in Wisconsin was damaged to the extent of 5 percent, while the estimated loss for winter wheat was 10 percent. In Nebraska and Missouri the loss also was 5 percent, but elsewhere losses were smaller. Loss of oats equalled that of wheat in Oklahoma and possibly Kansas, but elsewhere, with the exception of Illinois where an estimated loss of 10 percent occurred, there was little infection on oats.

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A record of the epidemic of 1938 must begin with events in the fall of 1937. Stem rust was plentiful on Hordeum jubatum late in August 1937 in southern Minnesota, Iowa, and northernmost Missouri, and also was present on late oats. This inoculum may have been carried southward by northerly winds early in the fall, for rust was found on oats near Guthrie, Okla., on October 24 and a month later at Pryor, Okla.; and Coffeyville, Kans. Wheat also was observed to be infected at Paoli, Okla., on October 24, and at four locations in Oklahoma in November and at one in Kansas. While summer survival of the rust and subsequent spread is possible, the northern source of inoculum appears to have been more likely in view of the extent of the area in which the rust occurred.

Overwintering

Although some of this infection may have survived the winter in Oklahoma or Texas, no evidence of survival was obtained in fields in which observations were made throughout the winter. Overwintering occurred in occasional fields in northern Mexico, however, and by April, despite the fact that there was less infection in general than usual, moderately heavy rust had developed near Sabinas Hidalgo, the area best situated for spread of inoculum to Texas.

Rust in Mexico

Southern Mexico apparently did not contribute to the epidemic in the United States in 1938, nor could it have furnished all the rust for northern Mexico.[1/] Observations and collections made in southern Mexico in February 1938 indicated that this region does not ordinarily take part in the interchange of rust from north to south and from south to north. In the first place, Marquis wheat, which is extremely susceptible to stem rust in the spring-wheat area of this country, has been grown in southern Mexico for a number of years because of its resistance in that region. In 1938, races 59 and 38 were the only ones identified from collections made in southern Mexico, except for one collection of race 24; and races 59 and 38 do not attack Marquis normally. Race 56 was not among those identified, although it was obtained in northern Mexico and in adjacent areas of the United States. Furthermore, nine different races were found in northern Mexico, all of which subsequently were found in the United States. This would indicate that, at least in 1938, the southern grain-growing areas of Mexico did not contribute inoculum to areas farther north.

Near the Texas border, however, observations in February and April indicated that there was enough stem rust on wheat to furnish the small amount of inoculum that apparently was scattered over central Texas.

1/ E.C.Stakman, W. L. Popham, and Robert C. Cassell. Observations on stem-rust epidemiology in Mexico (Abs.). Phytopath. 29: 22. 1939.

Rust was light on the whole in the grain-growing areas of northern Mexico, and no infection at all was found in the Laguna area around Torreon. Traces were observed in most fields near Saltillo and Villa Juarez in April; and several fields were heavily infected near Sabinas Hidalgo and others at Ramos Arizpe, Arteaga, and west of Saltillo. One of the fields at Sabinas Hidalgo, comprising about 100 acres, had an infection of about 50 percent in severity. This area was well situated for dissemination of inoculum by the wind into Texas. The accompanying map indicates these areas in relation to Texas. (fig. 1).

Possible overwintering in Oklahoma

The possibility that rust overwintered in scattered fields in Oklahoma during 1937-38 occurred to observers who examined fields in Oklahoma early in June. Heavy stem rust was found in a number of fields near Paoli and Eufaula on June 1 and 2. When average field-infection south of Paoli was 1 to 5 percent in severity, in a field just north of Paoli there was up to 50 percent of black rust in several centers that measured several rods across. The same was true of a field near Norman in this same area, in which some plants had been killed by the rust. The same type of infection was observed in a field near Checotah, in one at Muskogee, and in another at Chotoau, while rust in fields in intermediate areas varied from 1 to 10 percent in severity. The possibility of overwintering in these fields is supported by the fact that stem rust was present in these general areas late in the previous fall and that in those areas where no rust was found in November no such heavy centers were found in June. Furthermore, this spotting was not so general as was found in Missouri, where it presumably resulted from early spore showers. In the absence of definite evidence of winter survival, however, such as can be furnished only by following the rust from month to month throughout the winter, no final statement regarding overwintering in these fields of Oklahoma can be made.

Spring Development in the South and Northward Migration

Rust was first observed in Texas in the wheat plots at College Station on February 2. About third-generation infection was observed at Troy on March 6, and later observations indicated that a thin scattering of rust had appeared in San Antonio and other areas of southern and central Texas at the same time as that found at Troy. Weather maps indicate that conditions were favorable on January 16 for transportation of spores from the rust areas of northern Mexico into central Texas. Two stem rust spores were trapped by Mr. McFadden on January 15 at College Station. Additional inoculum probably was carried into Texas about March 4 or 5, to produce the second-generation rust found at San Antonio on March 27. Near San Antonio there was considerable early grain, and, as a result of excessive rainfall,

Figure 1.— Grain-growing areas of northern Mexico.

abundant rust developed in some of these fields fairly early in the season. No stem rust was found north of Waco by the middle of April, although the leaf rust epidemic that characterized the season was well under way throughout the State by April 1. Stem rust infection developed earlier, however, in the Waco-Temple section of central Texas than in the epidemic years of 1935 or 1937, and was abundant by the time the first infection was found at Denton, in the northern section (April 22). According to Mr. I. M. Atkins, stem rust was general in the Denton area by May 1, about two weeks earlier than in the normal year. Wheat also had headed from 10 days to 2 weeks early. However, May was cool, and this probably prevented heavy damage by rust in this section. Final development in the southern section was about 35 percent in severity; in the area north of Waco and Brownwood the average infection was 5 percent, with moderately heavy rust in some fields. Stem rust was not an important factor in the middle-western section and in the Panhandle.

Centers of heavy infection characterized the epidemic in much of the winter wheat region of the Southern States. On May 14, when the average field severity in Texas as far north as Waco was 10 percent, the rust was as heavy as 50 to 75 percent in scattered centers a rod or more across. This condition, which of course is not uncommon in this region, appeared to be the result of early, light spore showers, and was observed in many fields in the winter wheat area.

On May 11 and 12 rust was reported[2/] at Manhattan, Kansas, and at a number of places south of there. Inoculation of this area may have taken place during the period April 27-28, when a low-pressure area moved from the Texas Panhandle to central Wisconsin, the wind sweep on the east side of the low apparently carrying spores as far as western Illinois. Further inoculation occurred on May 3-5, when a low moved from southwestern Kansas across southern Kansas northeastward to western Wisconsin, as a result of which scattered third-generation infections were observed in Oklahoma, eastern Kansas, and Missouri on June 3 and 4. South winds on May 17 and 18 probably were responsible for the infection observed at Lincoln, Nebraska, on May 30, and for second-generation infections found in southwestern Missouri on June 3. New infection centers found in Missouri on June 4 appeared to be the result of wind-blown inoculum brought from the South on May 25. Field observations indicated that these periods of south wind were important in the winter wheat area, but on the basis of results of slide exposures it is to be concluded that spores were being transported by air at other periods during May also.

2/ C. O. Johnston in the Cereal Courier 30: 60. May 25, 1938.

Stem rust appeared later in western Oklahoma and Kansas. It was first reported on wheat at Woodward, Okla., on May 19, and was observed in Gove County, Kans., on June 5.

On June 5, when the wind sweep again was northward, there was abundant inoculum in the southern wheat belt. Harvest was in progress in northern Texas, with from 5 to 20 percent of rust in north-central counties; nearly all wheat was ripe in Oklahoma, with an average of 10 percent rust in most fields; while in southwestern Missouri and southeastern Kansas the infection averaged about 1 percent in severity. Primary infection was present in northern Missouri and Kansas. Spores were trapped as far north as Fargo, N. Dak., on this date, and field infection was observed on June 15 in west-central Minnesota and at Brookings, S. Dak., and was present as far north as Fargo, N. Dak. Although rust was first observed in the plots at Fargo on June 11, it is probable that this was the result of a very light spore shower during an earlier period of south wind.

Final development of rust in Oklahoma was as follows: Rust severity averaged about 10 percent in the south-central section at harvest time, and in the northeast and north-central section; in the east-central counties the rust varied from 10 to 25 percent in severity. In a more normal year an average infection of about 1 percent is to be expected.

Aside from the severe epidemic of leaf rust that characterized the season of 1938, another factor of considerable interest was the area of root-rot injury that extended from north-central Oklahoma, in a strip about 100 miles wide, through Kansas into southern Nebraska. The injury was at first reported as frost injury by some observers and was attributed by others to various causes. Considerable break-over of stems occurred in central Kansas, being more severe in the Caldwell-Kingman area than elsewhere. In some fields of hard wheat 95 percent of the stems were broken over, causing more damage than rust. A sequence of conditions which need not be given here, including, however, superabundant May rainfall resulting in very dense succulent growth, caused heavy damage. It is important, however, to emphasize the fact that this damage definitely was not due to stem rust.

There was considerable variation in the amount of rust that developed in Kansas, the greatest severity being observed in sections of the northeast. In southeastern Kansas, where wheat was ripe by the middle of June, rust was relatively light, varying from 1 to 15 percent between Wichita and Fort Scott, while west of Wichita infection was heavier, averaging about 25 percent in severity at Harper and Kingman. In the northwestern section, west and north of Hays, rust was light. There was sufficiently heavy infection in the northeastern part of the State, however, to damage

soft wheat. On June 18.when some fields of soft wheat were still in the medium dough, rust severity was 20 to 50 percent in the area between Troy, Hiawatha, Holton, and Manhattan. Rust also caused considerable damage between Lebanon and Marysville, where wheats were later than in other sections. Damage was not directly correlated in the various areas with severity of infection, but varied with the time of maturity of the grain.

The difference in susceptibility of hard and soft wheat is shown by comparative readings made at two different stages of development in northeastern Kansas. On June 6, when rust severity was approximately 1 percent on soft varieties, hard wheat showed only a trace; later, on June 18, when wheat was in the dough stage or already ripe, the range of 20 to 50 percent on soft wheat exceeded still more the 1 to 15 percent on hard wheat.

In Missouri, soft wheat in the northern half of the State was most seriously affected by rust. Severity reached 40 to 50 percent in a considerable number of the fields. Elsewhere there was less rust, although final severity in the west-central section between Nevada and Harrisonville averaged about 35 percent. By ripening when it did instead of a few days later, much wheat in this area escaped serious loss, although late fields were damaged considerably. In the Missouri Valley section east of Kansas City, in Jackson and Lafayette Counties, and north of the river in southern Ray County there was 30 to 40 percent of rust in many fields that were in the soft dough on June 16. Many fields in the soft-wheat area near St. Joseph developed 60 to 75 percent of rust by the time they were ripe, with considerable shriveling. Damage was less severe in the east-central section, but was heavy in Ralls and Marion Counties of the northeast, and there was considerable damage in some north-central counties. The same difference between the amount of rust on hard and soft varieties was observed in Missouri as was the case in Kansas.

Heavy rust developed in Nebraska in certain fields of the eastern section, from Pierce County south into Polk County on the Platte River and west to Hall County. Heavy rust also developed in Saline County and in the extreme southeast. Premature ripening as well as leaf rust, however, contributed to the shriveling. (Observations were not made in all sections.)

Rust on Barberries

Before rust appeared in southern Oklahoma, barberry bushes in the Northern States were becoming infected. Both pycnial and aecial stages appeared on barberries considerably earlier than usual. Pycnia were ob-

served in Ohio on April 14; April 19, the date of observation in Illinois, is the earliest on record in that State; and in only one year has infection on barberries in Minnesota been observed earlier than in 1938. Aecia developed during the last week of April and the first week of May in the territory from Ohio and Michigan west to Missouri, Iowa, and Minnesota (fig.2); and in most of this area aecial infection developed on barberry bushes from 4 to 6 weeks before uredial infection appeared on grains away from known locations of bushes. Barberries also rusted in Kansas, Colorado, Nebraska, North Dakota, and Montana. Spread of rust from barberries was observed on May 24 and 25 on grasses in two counties in Missouri, and on wheat in Ohio on May 27, on grass in Wisconsin on June 1 and 2, on grass and rye in Iowa on June 1, on grass in Minnesota on June 6, and on rye in Wisconsin on June 6. Following this, spreads were widely distributed and unusually abundant, the same favorable weather conditions that promoted rust development in general operating toward the development of rust near the bushes.

It is becoming increasingly evident as time goes on, however, that the obvious spread of rust from infected bushes is not the only, or necessarily the most destructive, result of barberries. Production and perpetuation of new and virulent rust races on barberries have been discussed elsewhere, and new evidence is presented again in 1938 in the results of the physiologic race surveys. There is also the significant and interesting find of a large barberry bush in western Minnesota in 1938 which was located by following up the clue offered by identification of the unusual rust races 65 and 147 collected in that section, and by tracing the telial stage of rust on quack grass to the bush.

Slide Exposures

Slide exposures indicated that stem rust spores were in the air as far north as Nebraska during eight periods in May and also during eight periods, of from 1 to 3 days each, in June. Up to the middle of May spores were not caught north of Nebraska and southwestern Iowa. Although the periods of spore showers are not so sharply delimited as in some years, there are a number that are of particular interest in connection with field observations that already have been described. Wind was seuth from Oklahoma City to Falls City, Nebr., on May 3 and 4, and 960 spores per square foot of ground surface were trapped at Falls City on the 3d and 384 at North Platte, Nebr., during the 48 hours. During the period May 16-19 winds were north and northwest from Oklahoma City, and spores were trapped as follows:

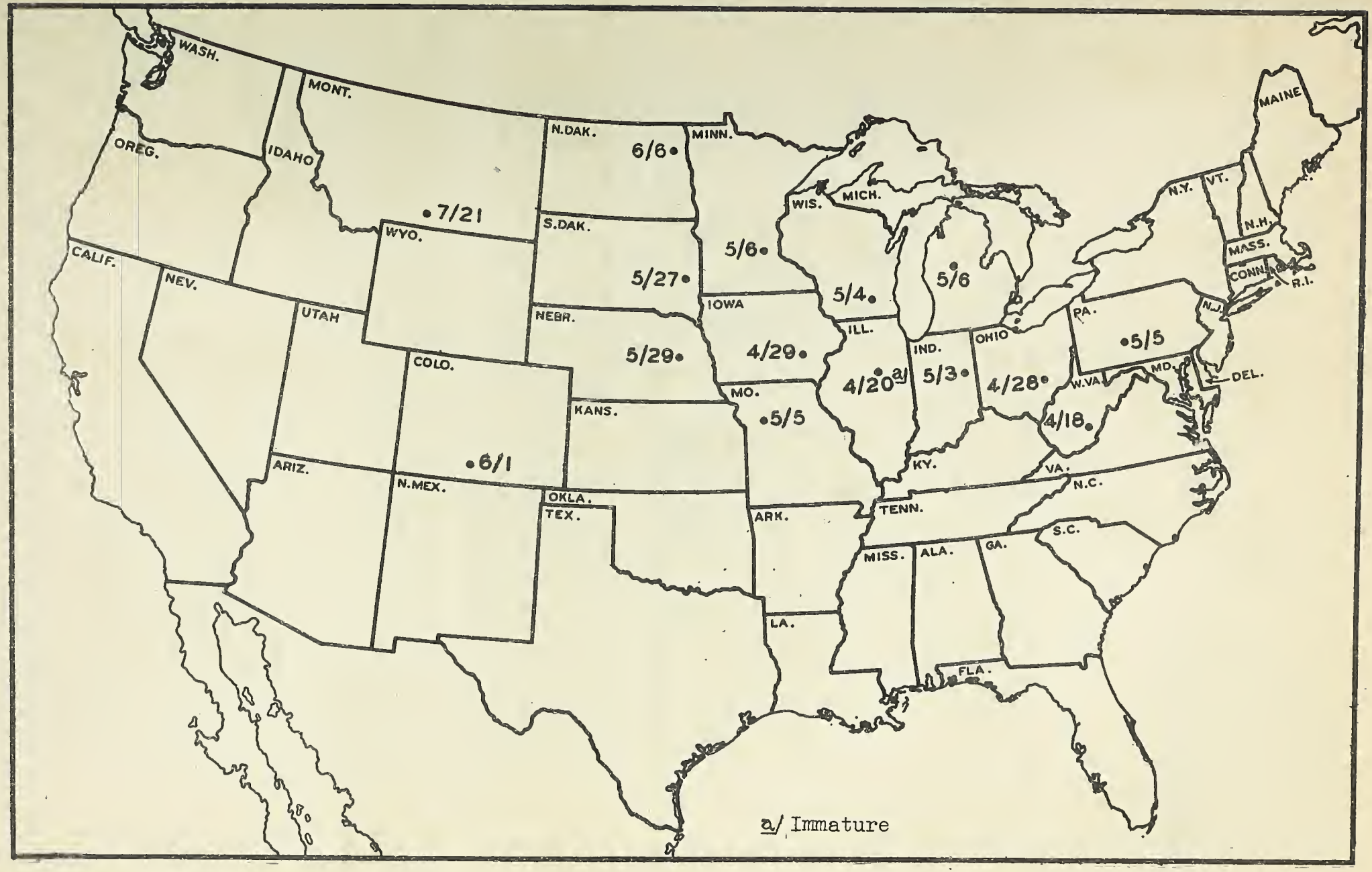

Figure 2.— Aecial infection on barberry bushes (earliest reported only).

	May 16	May 17	May 18	May 19
Oklahoma City, Okla.	1,296	1,152	432	288
Lincoln, Nebr.	48	0	0	0
Falls City, Nebr.	1,536	9,120	720	480
Beatrice,Nebr.	672	816	3,322	384
North Platte,Nebr.	1,440	576	0	576
Turin, Iowa	48	0	0	96

Stem rust spores apparently reached Lansing, Mich., on May 22 at the rate of 528 per square foot, although there had been one or two spores per slide observed earlier. On May 25, winds were north and northeast from Dodge City, Kans., to Minneapolis, Minn., and east to Green Bay, Wis. On these twp days spores were caught as follows:

	May 24	May 25
Dallas, Tex.	95,616	33,600
Oklahoma City, Okla.	96	6,192
Falls City, Nebr.	6,000	1,680
Beatrice,Nebr.	1,440	528
Madison, Wis.	192*	0

*First to be caught at Madison

On June 4 and 5 there was a general northward wind sweep, already mentioned, and spores were trapped from Texas to North Dakota, the number varying from 18,240 at Dallas and 34,560 at Oklahoma City (on the 5th) to 960 at Brookings (during the 48hours) and 192 at Fargo. At corresponding stations eastward, as in Missouri, Iowa, and Minnesota, spores also were caught on slides, but in smaller numbers.

The period of June 13 and 14 was outstanding so far as inoculation of a wide area was concerned. Wind was south and southeast from Dallas, Tex., to Moorhead, Minn., Bismarck, N.Dak., and Marquette, Wis. Spores were trapped as follows:

	June 13	June 14	
Texas	3,648	13,056	
Oklahoma	92,864	86,352	(see fig.3)
Kansas	154,800	181,200	
Missouri	738	1,536	
Nebraska	37,296	17,040	
Iowa	18,480	2,880	
Minnesota	26,688	5,568	
South Dakota	10,800	1,824	
North Dakota	1,248	96	

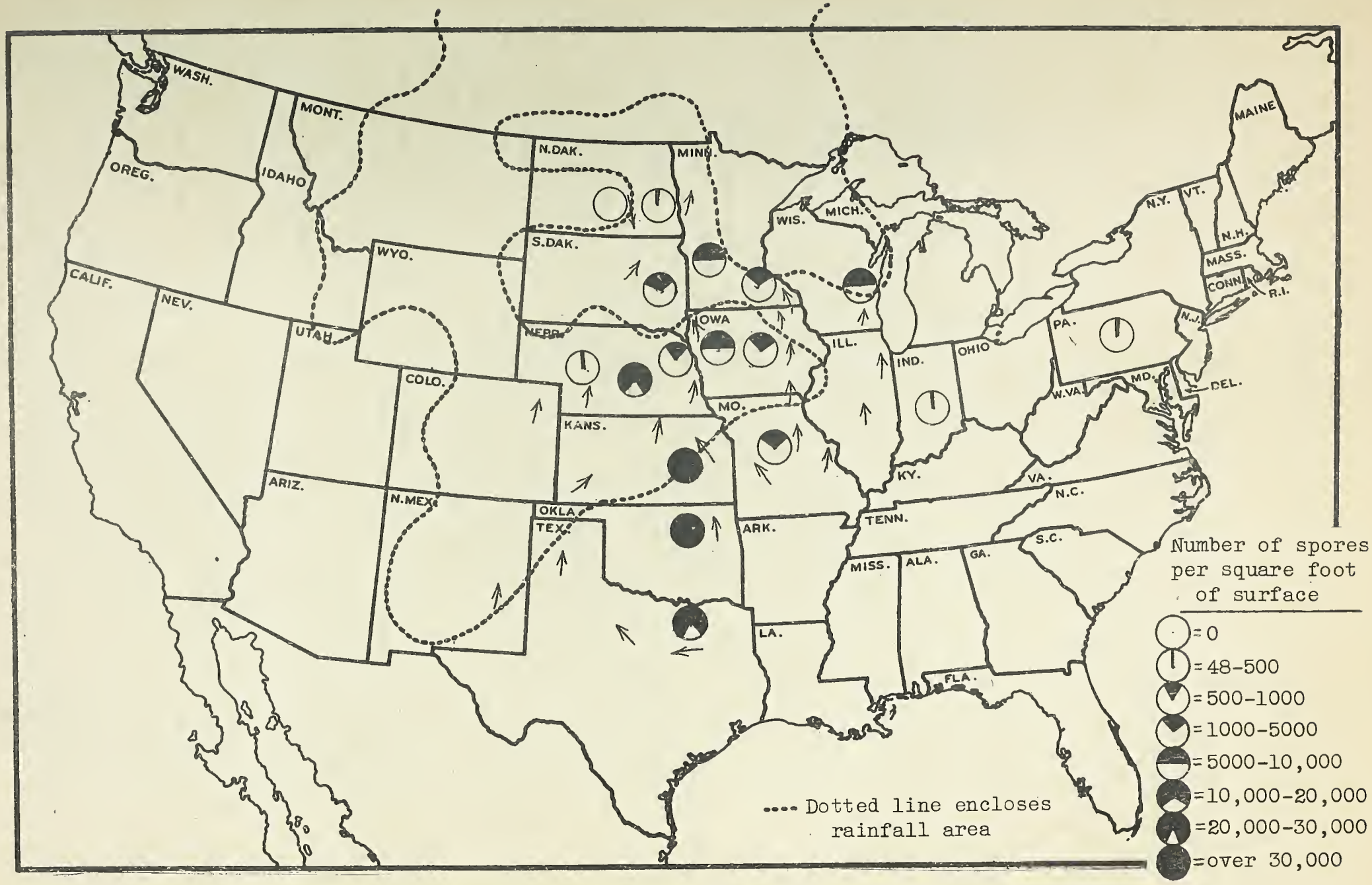

Figure 3.——Stem rust spores caught on vaselined slides exposed on June 14, 1938, wind direction, and rainfall.

Rain fell over most of this area at some time during June 13-15: on the 13th in eastern South Dakota; on the 14th in Kansas, Nebraska, northwestern Missouri, most of Iowa, in Minnesota from St. Paul and slightly west northward to Winnipeg and beyond, and in parts of North Dakota; on the 15th in sections of the spring wheat area not covered previously. Effects of this inoculation began to make their appearance on June 22 and 23 in fields of susceptible wheat and barley from Nebraska northward as far as southern Manitoba, Canada.

Intervening periods in which spores were present in the air at a number of stations, which will not be described in this report, included the following: May 10-11, May 22, May 26, May 30-31, June 1-2, June 6, and June 8-9.

In the spring-wheat area spores were trapped somewhat later in May than was the case in the preceding 3 years, and in general the spore load of the air was lighter than in 1937. Furthermore, the largest number of spores found on any one slide in June was less than one-third the largest number found in 1935; 263,808 per square foot were counted on the slide exposed at California, Mo., on June 13, 1938, as compared with 921,600 at Waverly, Nebr., on June 29, 1935. The first spores to reach the spring wheat stations, aside from a few caught in Minnesota in May and a few questionable spores caught in South Dakota, were found on Minnesota slides on June 2, in South Dakota on June 1, and in North Dakota on June 5. The first stem rust in quantity to come in was observed on June 5 in South Dakota, with 960 per square foot trapped during a 48-hour exposure; on June 8 in Minnesota, with 2,496 trapped at New Ulm; and on June 13 in North Dakota, with 1,248 at Fargo. During the month of June, however, spore showers were frequent, there being six periods in which spores were precipitated over the Dakotas and Minnesota. Rain fell in some part or all of the spring wheat area on most of the days on which spore showers were noted. Two periods followed in the first 10 days of July. This would appear to constitute as nearly continuous bombardment as might be expected. Although the spore load was not so heavy at a given time as was true in general in 1937, the total number of spores trapped during the season probably was larger.

Slide exposures in the past have indicated that few or no spores are to be found on slides exposed in Montana; this year, however, they occurred in quantity on July 9--over 10,000 per square foot of surface. Numbers found subsequently were smaller. The extension of the epidemic into northeastern Montana already has been mentioned.

The leaf rust epidemic also was reflected in the number of spores of this rust found on slides. Spores appeared on slides earlier in Missouri and Nebraska than in the past 3 years and were present on most slides. Leaf rust in quantity on Nebraska slides was first noted in 1936 on May 31, in 1937 on May 24, and in 1938 on May 2 and 3. The number on May 2-3 was about six times as heavy as on May 24 of the previous year.

Spring Wheat Area

Spring grains at the time of rust inoculation were in optimum condition for the development of infection. On June 1, according to "Crops and Markets" of the U. S. Department of Agriculture, spring grains were thriving, their condition being higher than on any June 1 since 1923. There was heavy growth of grain in Minnesota and in sections elsewhere in the spring wheat area. During June temperatures were normal or slightly above, but precipitation was uneven and in some sections insufficient for the crop. Above-average rainfall fell in southeastern Minnesota, in the middle division of South Dakota, and in the western third of North Dakota. In North Dakota showers were frequent after the 9th, and at the close of the month soil conditions in the State were good. In the northern two-thirds of Minnesota, however, moisture was needed by this time, and in western South Dakota and in the upper James Valley there was only from 6 to 10 inches depth of moisture. Temperatures during July were slightly above normal, and where there was enough rain the conditions were very favorable for rust development. Temperatures averaged from 84° to 87° F. at Minnesota stations in the grain area of the State and from 81° to 86° at North Dakota stations. During the first week of July showers were frequent. Rain fell at all North Dakota stations on July 1, 3, 4, and 5, and at some stations every day between July 1 and 11. Rainfall for the month was 137 percent of normal, in comparison with 77 and 78 percent of normal in South Dakota in June and July.

Under these conditions, therefore, heavy rust developed by harvest time throughout the spring wheat area, with the exception of those areas where moisture was deficient or other factors operated to prevent rust development, or where resistant varieties of wheat predominated. Drought prevented rust losses in western South Dakota and in some eastern sections; this was true also of south-central North Dakota and a tier of counties just west of the Red River Valley counties. In addition, grasshoppers caused so much damage in southern and southwestern North Dakota as almost to nullify stem rust. In Minnesota the preponderance of Thatcher wheat kept the aggregate rust loss low. Rust was destructively severe, on the other hand, in North Dakota except as noted, reaching almost maximum severity in the southern Red River Valley, in Pembina County of the northeast, and in sections of northwestern North Dakota. In South Dakota the heaviest infection occurred in the south-central section from Aurora County west to Tripp and Lyman Counties and farther north from western Spink County to Potter County. Durum wheats escaped heavy loss because of their comparative resistance to the most prevalent rust strain.

Physiologic-Race Survey

The stem rust epidemic in 1938 was caused primarily by physiologic race 56, which was the most prevalent race for the fifth consecutive year. This race was isolated from 83 percent of all the collections obtained in the United States and constituted about 66 percent of the isolates. In reality, probably upwards of 90 percent of the inoculum was of race 56. Never before, since the physiologic survey was started on an adequate scale, has any single rust race been so predominant as race 56. When a single race predominates as did 56 in 1938, this fact must be taken into consideration in explaining varietal behavior. Obviously the durum wheats, most varieties of which are highly resistant to 56, would tend to escape damage in a year like 1938; and there was very little rust on them, except on an occasional field of Kubanka, which, however, constitutes a relatively small percentage of the total. Furthermore, Thatcher wheat, now so commonly grown in the spring wheat regions, is moderately to highly resistant to race 56 and escaped infection almost entirely in 1938, while Ceres, Marquis, and certain other spring wheat varieties were virtually ruined by rust in many localities. It should be emphasized that too much dependence cannot be placed on the results of testing varieties against rust in a year like 1938 unless an artificial epidemic is produced with a number of the physiologic races. Under natural conditions the results of the survey show very clearly that the varieties or hybrids would be tested for practical purposes only against race 56.

Although four other races were fairly widely distributed and quite prevalent, they were not nearly so abundant as race 56. They are given in order of prevalence. Race 38 was identified in 15.5 percent of all uredial isolations, race 19 in 6.4 percent, race 17 in 3 percent, and race 11 in 2 percent. It is important to note that all four of these races attack durum wheats. Nevertheless there was very little rust on the most commonly grown varieties of durum in North Dakota. It should be explained that the percentage of isolates as given for the different races merely indicates the number of times this race was isolated from rust collections, and it does not show the percentage of rust in that collection belonging to the different isolates. Frequently two or more races are obtained in the same collection, and the relative amounts of the different races also is important. Quite often, for example, races 56 and 38 were identified from the same material, and race 56 often constituted 90 percent or more of the inoculum.

Collections of rust on barberry yielded the wheat strain of rust in most cases; 78 percent were Puccinia graminis tritici, 19 percent were P. graminis secalis, and 12.5 percent were P. graminis avenae. These

percentages indicate a decrease in the prevalence of the rye strain and an increase in the oats strain. Race 56 was most commonly isolated from barberries, as it was from wheat.

In the identification of races of Puccinia graminis tritici from barberries, those most commonly isolated were as follows: Race 56 occurred in 36.2 percent of aecial isolations, 38 in 9.9 percent, 36 in 7.3 percent, 17 in 7.3 percent, 19 in 6.5 percent, 34 in 6.1 percent, 21 in 5.3 percent, 49 in 4.9 percent, and 11 in 4.2 percent.